Concentration of Solutions

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In chemistry we often work with solutions. A solution is a mixture of two or more pure substances that form a homogeneous mixture. A solution contains two parts. The solute is the substance being dissolved into the solution. The solvent is the substance that dissolves the solute.

The concentration of a solution is the ratio of the amount of solute to the amount of solution.

$$\text{concentration} = \frac{\text{amt. solute}}{\text{amt. solution}}$$

When the ratio is large the solution is concentrated. When the ratio is small the solution is dilute.

Concentration can be measured using one of several different units. There

are three common sets of units we will use: percent concentration, molar concentration and parts per million (ppm).

Percent Concentration

To calculate percent concentration we use the equation:

$$\%C = \frac{\text{amt. solute}}{\text{amt. solution}} \times 100\%$$

Masses are measured in grams and volumes in millilitres.

Example #1: Calculate the concentration of a glucose IV solution in which 5.0g of sugar are dissolved to make 250 mL of solution.

$$\% C = \frac{\text{amt solute}}{\text{amt solution}} \times 100\%$$

$$= \frac{5.0\,g}{250\,mL} \times 100\%$$

$$= 2\% \,(w/v)$$

∴ the concentration is 2% (w/v).

The notation (w/v) tells us that the solute was a solid measured in grams, and the

solution was a liquid measured in mL. Other combinations are possible:

% (w/w) - solid solute, solid solution.

% (v/v) - liquid solute, liquid solution.

% (v/w) - liquid solute, solid solution

These concentrations are often found on household products and some medical solutions.

Molar Concentration

To calculate molar concentration we use the equation:

$$c = \frac{n}{V}$$

- c ← molar concentration.
- n ← amount of solute in moles
- V ← amount of solution in litres.

Example #2: Calculate the molar concentration when 0.168 mol of NaCl is dissolved in 0.10 L of solution.

$$C = \frac{n}{V} = \frac{0.168\ \text{mol}}{0.10\ \text{L}} = 1.68\ \text{mol/L}$$

∴ the molar concentration is 1.68 mol/L

↑ molar concentration is always in mol/L.

Example #3: What is the molar concentration of a solution when 10.0g of NaOH is dissolved to make 250 mL of solution.

$$M_{NaOH} = 1 \times 22.99\ \text{g/mol} + 1 \times 16.00\ \text{g/mol} + 1 \times 1.01\ \text{g/mol}$$

$$= 40.00\ \text{g/mol}.$$

$$n_{NaOH} = 10.0\text{g} \times \frac{1\ \text{mol}}{40.00\ \text{g}} = 0.25\ \text{mol}$$

$$V = 250\,mL \times \frac{1\ L}{1000\ mL} = 0.25\ L$$

$$C = \frac{n}{V} = \frac{0.25\ mol}{0.25\ L} = 1.0\ mol/L.$$

$\therefore$ the concentration is 1.0 mol/L.

Molar concentrations are mostly found in chemical laboratories.

Parts per Million (ppm)

Parts per million is used for very dilute concentrations. 1 ppm is defined as one part solute per 1 million parts solution. So

$$1\ \text{ppm} = \frac{1\text{g solute}}{10^6\text{g solution}}$$

Since water has a density of 1 g/mL then

$$1\ \text{ppm} = \frac{1\text{g solute}}{10^6\text{mL solution}}$$

$$1\ \text{ppm} = \frac{1\text{g solute}}{1000\text{L solution}} = \frac{1\text{mg}}{\text{L}}$$

Example #4: An analysis shows that 250 mL of pond water has a dissolved oxygen concentration of 2.2 mg. What is the oxygen concentration in ppm?

$$C = \frac{\text{amt solute}}{\text{amt solution}}$$

$$= \frac{2.2\text{ mg}}{250\text{ mL}} \times \frac{1000\text{ mL}}{1\text{ L}}$$

$$= \frac{2.2\text{ mg}}{0.25\text{ L}}$$

$$= 8.8\ \frac{\text{mg}}{\text{L}} = 8.8\text{ ppm}$$

∴ the concentration is 8.8 ppm

P 126 P 1, 2

P 128 P 4, 5, 6

P 133 P 17, 18.